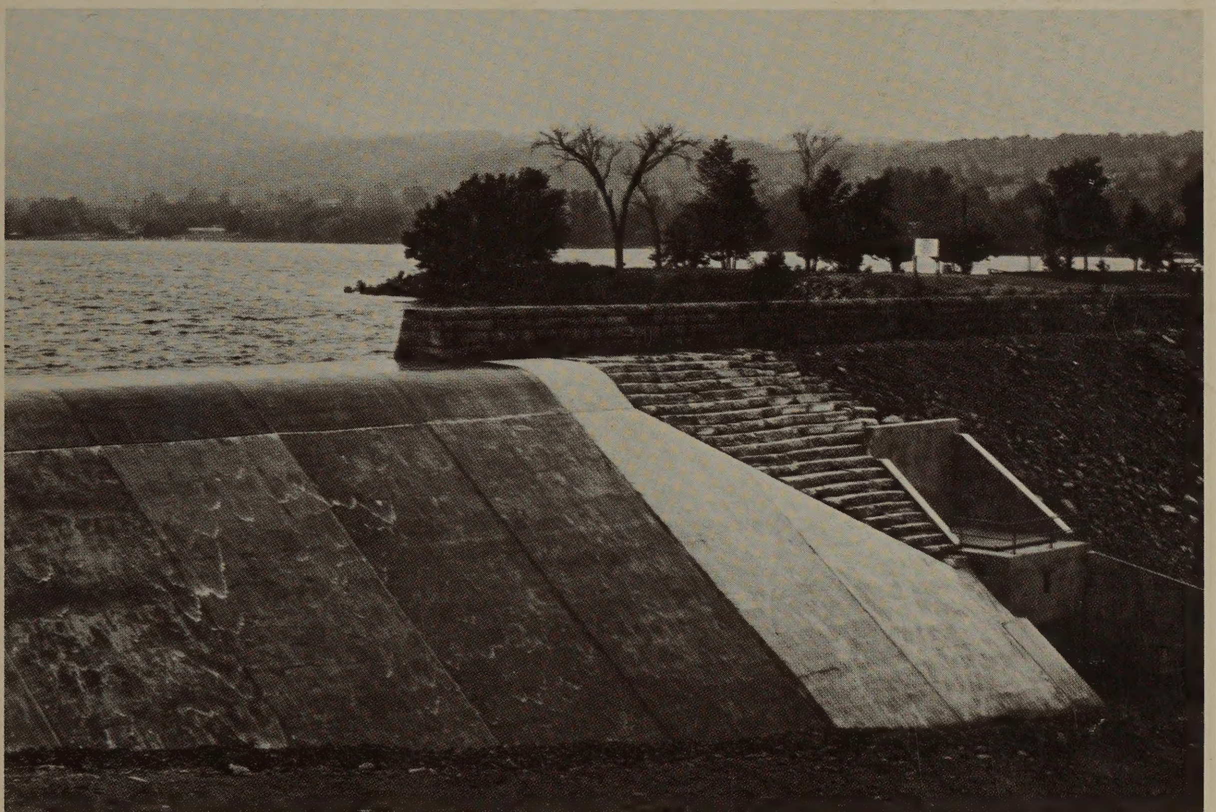
USE OF REINFORCED EARTH® FOR REPAIR OF THE JAMESVILLE DAM



By

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Introduction

The New York State Department of Transportation's first Reinforced Earth® project was completed in 1977. Since then, the use of this material has resulted in substantial savings and good performance on an increasing number of projects.

To date, the Department has used Reinforced Earth in the construction of retaining walls, bridge abutments and associated wingwalls, and to strengthen an existing dam.

The dam project is presented in this case history. Site evaluation, design, construction and performance observations are discussed.

Overview

The inspection program for water impoundment structures under the National Dam Safety Act of 1972 has identified numerous dams as unsafe. The Phase I report of the inspection program represents an overview analysis and evaluation of a dam's safety. Under the law, an unsafe rating requires immediate safety measures to be initiated, followed by an in-depth analysis to either verify the safety of the dam or to design and implement corrective actions.

Among those dams judged unsafe are some which are part of the New York State Canal system. They were originally designed as feeder dams. But, subsequent modifications to the canal system, and abandonment of sections, have created a recreational role for many of these dams. The Jamesville Dam is one of these. Its recreational value was considered too important to take the most direct safety treatment alternative: completely drain the lake and remove the dam. Instead, a Reinforced Earth structure was selected to strengthen the dam.

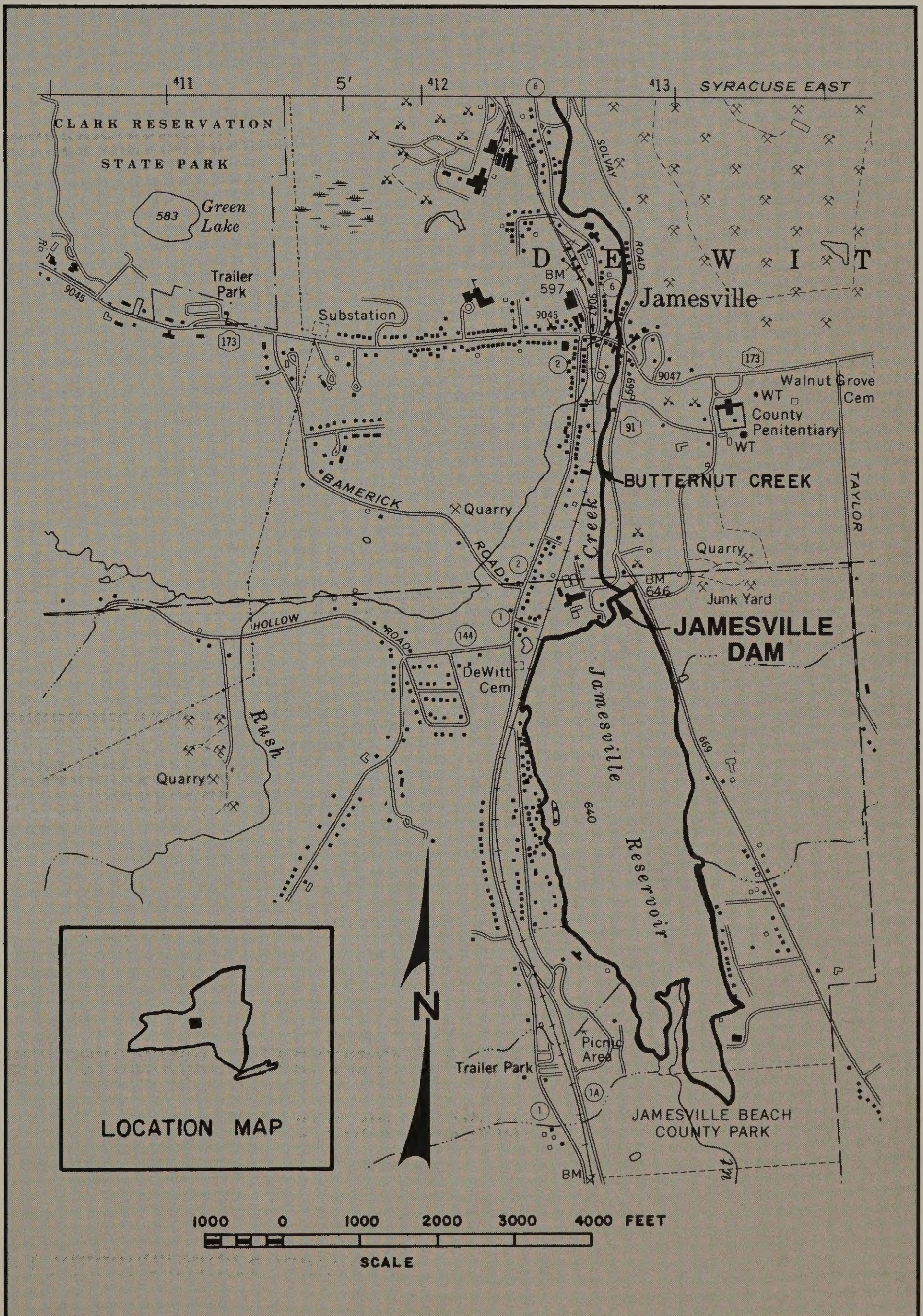

Figure 1. Location map.

Figure 2. Jamesville Dam before repairs.

Description of Dam

The dam is situated on the Butternut Creek south of Jamesville (See Figure 1). Design and construction of the dam took place between 1872 and 1874. It is a stone masonry gravity structure about 500 ft long, incorporating a 200 ft overflow spillway on the east side. The maximum height is about 48 ft, measured from the bottom of the foundation. The foundation beneath most of the dam is limestone. However, the 40 to 50 feet of dam length next to the west abutment is supported on timber piles with a timber cut-off wall to rock. An overall view of the front of the dam is shown in Figure 2.

The dam's internal structure was revealed by three horizontal and three vertical borings made through it immediately after the Phase I inspection report. While outward appearances and the plan information indicated that the dam was entirely stone masonry, the borings showed the interior to be of cyclopean construction: concrete with limestone fragments used as bulk filler. This meant that the exposed masonry was both facing material and formwork for the interior filling. The cross-section is shown schematically in Figure 3. There is no available recorded evidence authorizing a change in cross-section.

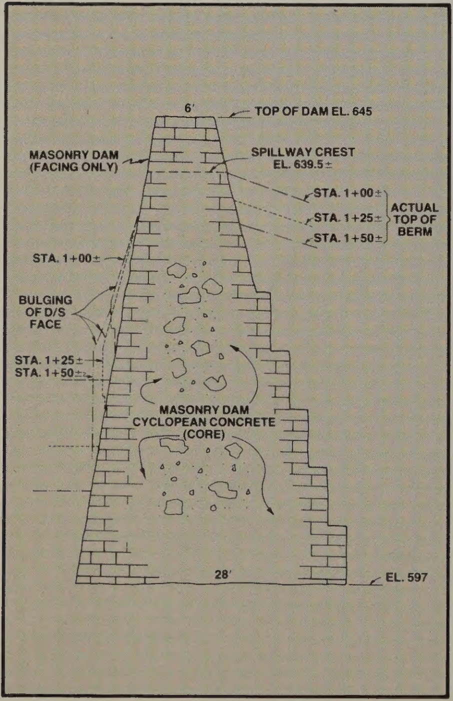

Figure 3. Typical section–Jamesville Dam.

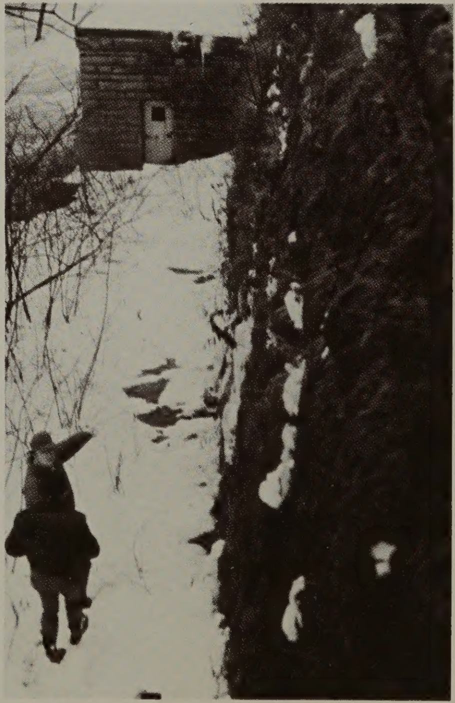

Figure 4. Bulging of down stream face.

This leads to a bit of conjecture: was this type of construction actually planned and were plans simply schematic or was some profiteering involved? Did money run out during construction requiring some cost cutting measures? It is interesting to note that the State Engineer's construction report of January, 1874 contains a request for an additional $25,000 to complete the dam because of damage caused by a deluge. This sum, if granted, would have brought the total cost of the project to $130,000.

Evaluation of Existing Conditions

After the Phase I report, many site inspections were made of the dam exterior. The main cause for concern was a general bulging of the downstream masonry facing. Figures 4 and 5 show the bulging blocks and open deep joints. This outward movement, amounting to as much as a foot (See Figure 3), has been largely attributed to freeze-thaw cycles of water behind the blocks. The area of movement was generally outside the limits of the overflow spillway, beyond the gatehouse, extending to the west abutment. Water seepage and occasional flows had also been observed from open joints between blocks. The absence or deterioration of mortar in joints was extensive. However, in spite of these losses, maintaining the pool had never been a problem.

Analysis of the cores from horizontal and vertical borings through the dam also included compressive strength testing. A borehole camera survey was made in each of the boreholes. The interior was found to be intact although the mortar or concrete between rock pieces had a low strength, i.e., between 770 and 1630 psi. This concrete had also eroded in places under the action of drill water.

Mass stability analyses were made for overturning and sliding with various degrees of hydrostatic uplift. The computed safety factors for each analysis with full uplift at two stations were between 0.9 and 1.1. These results verified a hazardous situation.

Another mode of failure not analyzed but quite possible was shear or overturning at a horizontal crack at intermediate dam heights. The low strength of the cyclopean concrete, the presence of cracks through it, and the lateral earth force from long-term siltation build-up on the reservoir side acting

Figure 5. Open joints in down stream face.

with the water force could make this type of failure a distinct possibility.

Stabilization Treatment Design

Any treatment for stabilizing the dam had to satisfy a number of objectives and site constraints. Stability had to be accomplished without relocating an adjacent county road or constricting the spillway flow in the channel parallel to the toe of the dam. Furthermore, turbulence had to be minimized on the spillway. Also, spillway flow energy had to be dissipated to prevent scour of the roadway and to allow redirection of the flow to the roadway culvert. Near-peak discharges are shown in Figures 6 and 7. An overview of the project-treatment features is shown in Figure 8.

The delicate condition of the dam, the presence of the berm of silt against the upstream face and public pressure to maintain a pool dictated that the existing dam be strengthened rather than replaced. It was decided, from among various alternatives, to buttress the existing dam with a wedge of compacted rock fill. However, flow over a rough rock spillway surface would be destructive. Calculation indicated a flow velocity at the spillway bottom of as much as 40 ft per second under a peak discharge condition. Therefore, a smooth spillway slope was required with an immediate dissipation of energy in the adjacent channel to protect the county road and re-orient this discharge, 90-degrees to flow, toward the existing culvert and then down Butternut Creek.

Covering the rock wedge in the spillway area with a smooth concrete surface presented another design prob-

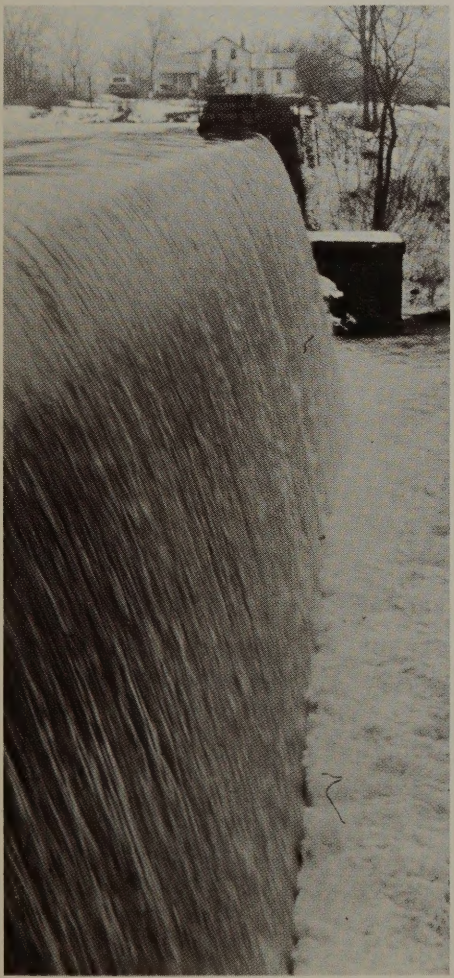

Figure 6. Near-peak discharge over spillway.

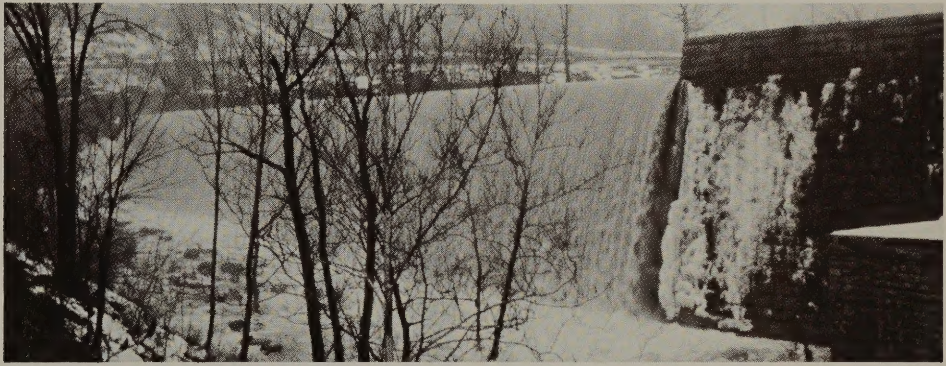

Figure 7. Near-peak discharge over spillway.

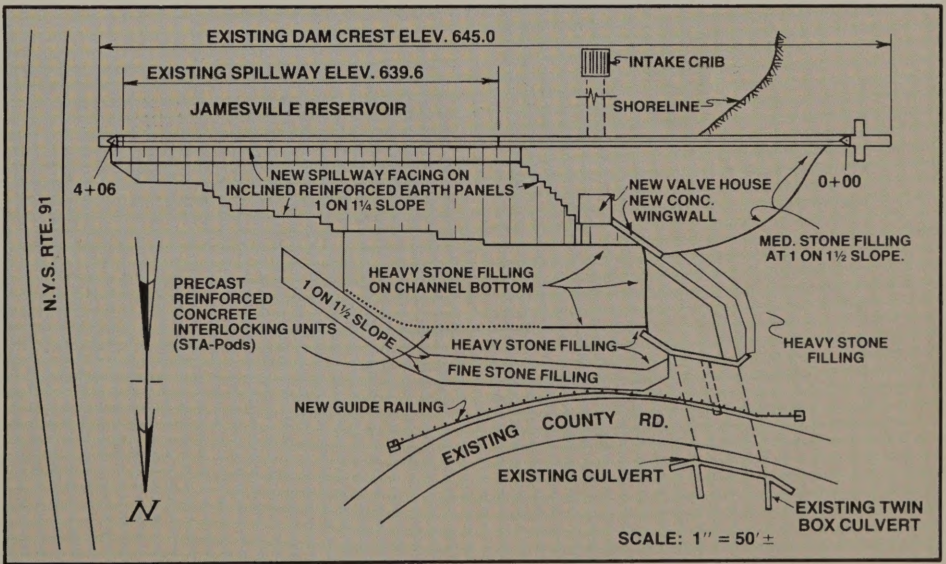

Figure 8. Site plan of dam stabilization and rehabilitation.

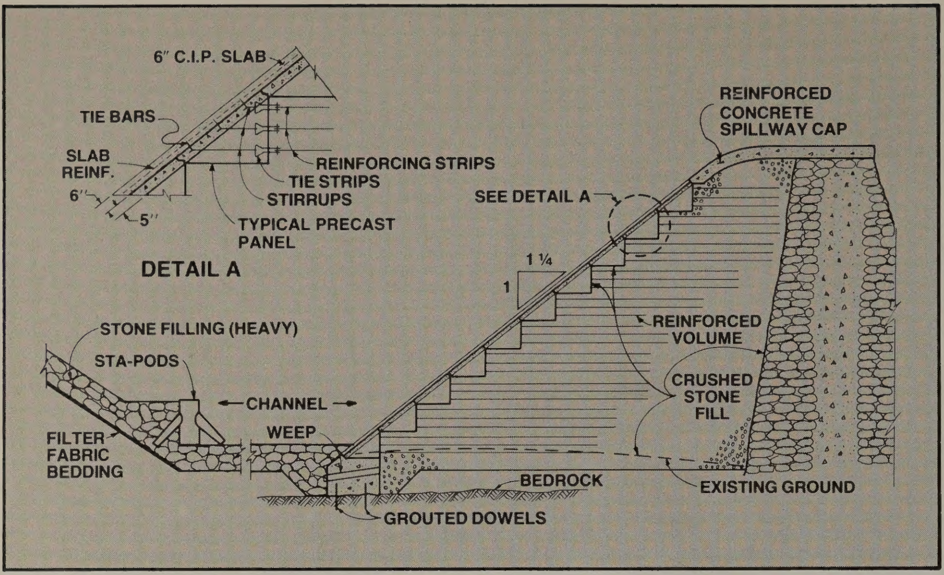

Figure 9. Typical section spillway buttress and spillway.

lem: the possibility of a seepage pressure build-up within the rock buttress over an extended period of time. This concern, and the steep slope of the rock buttress (1 vertical on 1.25 horizontal) needed to minimize encroachment into the narrow Butternut Creek channel at the toe of the spillway, required reinforcement of the rock fill. The rock buttress beyond the spillway, however, could be designed to a flatter (1 on 1.5) slope and did not require reinforcement. The rock fill was 8 in. top size, graded down through 1 to 2 inches.

The first design concept considered in the spillway area was to place wire mesh over the sloping rock face tied into horizontally placed wire mesh reinforcement at 18-inch intervals within the rock buttress. This steel reinforcing system would take care of rock-fill stability. The next step required for this design was a continuous concrete slab up the face of the reinforced rock wedge or buttress encapsulating the sloping wire mesh reinforcement. Discussion with contractors led to the conclusion that setting forms and providing uniformly finished surface on the irregular rock face would be an extremely difficult, if not impractical, task.

The solution to the problem was to replace the rock buttress in the spillway section with a Reinforced Earth sloping buttress. Inclined panels have been used extensively in the construction of massive coal storage facilities. Figure 10 shows initial placement of these panels in this project.

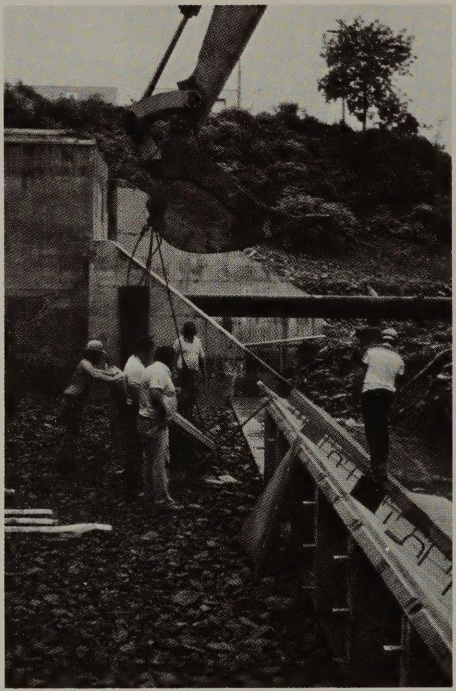

Figure 10. Initial placement of Reinforced Earth slope buttress.

The choice of inclined panels, however, did not completely solve the problem because the fast flowing water would cause cavitation of the concrete at panel joints. This problem was solved by pouring a six-inch-thick reinforced concrete slab on top of the panels. The slab was tied to the panels by two methods. First, the panels were specially cast with steel tie bars protruding for attachment of the slab's reinforcing steel. Secondly, the panels were cast with a rough surface finish to promote bonding to the slab. Setting forms on the sloping panels for the slab pour was no longer a problem (See Figure 11). The typical section (Figure 9) shows these details. Note that there is structural continuity of the slab to the reinforcing strips.

Provision for quickly dissipating the energy of water coming off the spillway was the next problem to be resolved. The spillway flow velocity was estimated at 40 ft per second and would impact the opposite bank less than 40 ft away. This bank supports a county road which had to remain unaffected by this project. In addition, water from the spillway must turn 90 degrees, run parallel to the new toe of dam and then change direction again to flow away from the site through a culvert. The design scheme adopted was to line the existing rock channel next to the spillway toe and the opposite stream bank with a three foot thickness of heavy stone fill. Heavy stone fill consists of rock with 50% to 100% of the pieces heavier than 600 lbs, and not more than 10% smaller than six inches. In addition, a revetment system was required for further protection of the bank supporting the existing roadway. A patented system of precast concrete units called Sta-pods was used for this purpose (See Figure 12). A typical cross-section illustrating the stream channel and bank-protection system is shown in Figure 9.

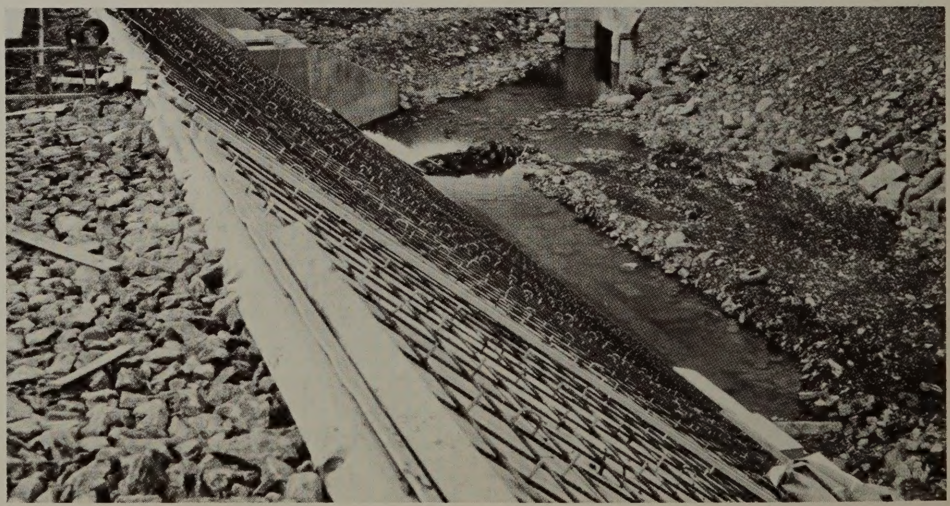

Figure 11. Reinforcing steel tied to inclined panels for slab pour.

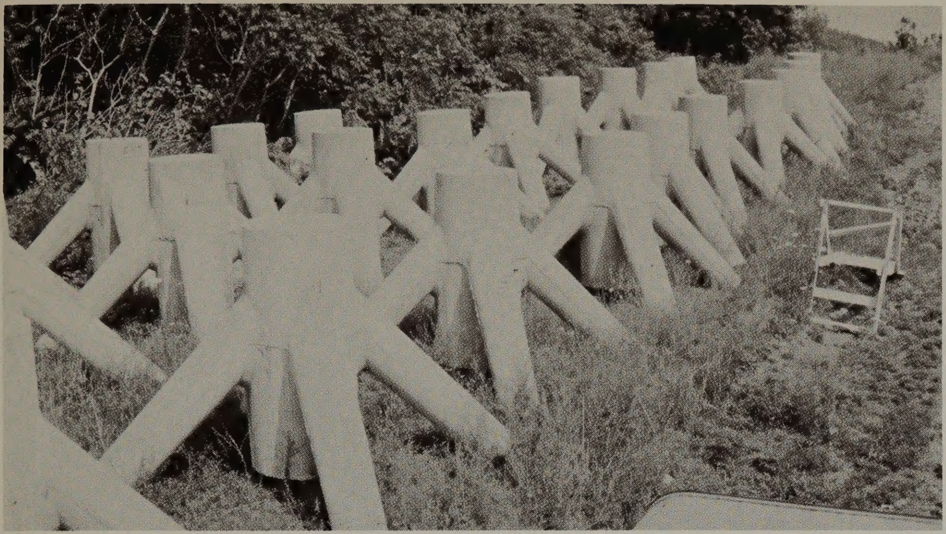

Figure 12. Precast concrete Sta-pods for additional bank support.

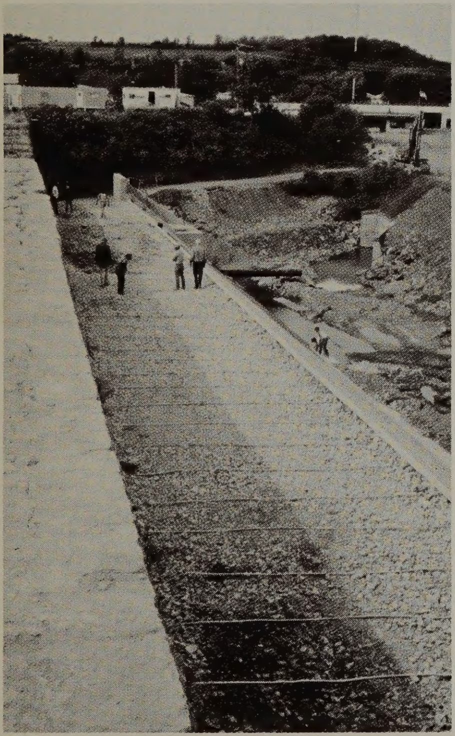

Figure 13. Reinforcing strips before backfill.

Construction Procedure

The contract was let and commenced in the fall of 1979. The Reinforced Earth buttress phase of the project was installed in six weeks. Only a few problems were experienced for this part of the project. For instance, the rock surface was discovered to be considerably lower than anticipated along the toe of the Reinforced Earth spillway section. This was resolved by extending the toe of the Reinforced Earth slope to a lower elevation farther into the channel and filling back up to channel grade with heavy stone fill.

Originally, compaction was to be accomplished on 12-inch lifts with the specified number of passes related to the particular types of compaction equipment used. This was changed to compaction with hauling and spreading equipment to eliminate the possibility of fracturing the reinforcing strips (See Figure 13).

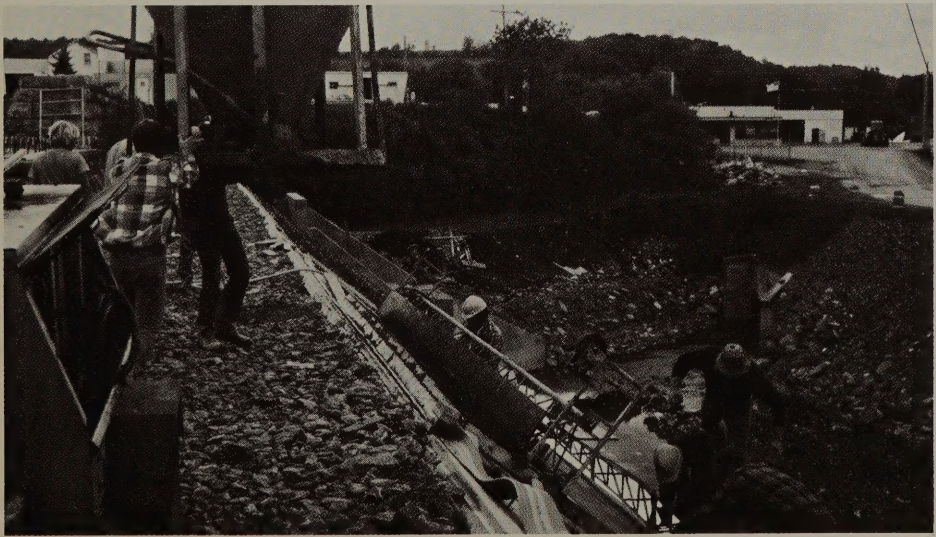

Figure 14. Concrete pour over Reinforced Earth facing.

The only other significant construction difficulties were the concrete pours on the Reinforced Earth face, and the curved pour for the spillway cap. In both cases, a low slump was critical (See Figures 14, 15, and 16).

Summary and Conclusions

Identified as unsafe under the National Dam Safety Act of 1972, the Jamesville Dam was evaluated for corrective treatment.

This stone masonry and cyclopean concrete structure, more than 100 years old, exhibited bulges, seepage and occasional flow lakes in numerous locations.

Reinforced Earth was selected to buttress the spillway section of the dam. Special surface modifications of the Reinforced Earth slope-panel permitted bonding of an additional six-inch-thick cast-in-place concrete slab to the spillway surface.

Figure 15. Finishing the concrete slab.

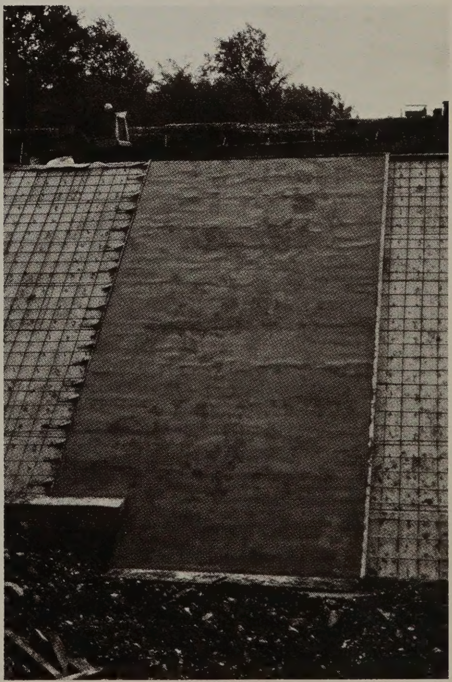

Figure 16. Completed concrete slab section.